Government Gazette

EXTRAORDINARY

OF

WESTERN AUSTRALIA.

[Published by Authority.]

No. 26.] PERTH: FRIDAY, MAY 20. [1887.

No. 3083.—C.S.O.

Colonial Secretary's Office,
Perth, 19th May, 1887.

1937/87

HIS Excellency the Governor directs the publication of the following Letter from the Crown Agents for the Colonies, enclosing a copy of a Report by Sir John Coode on the question of the proposed Harbor Works at Fremantle.

By Command,
MALCOLM FRASER,
Colonial Secretary.

FREMANTLE HARBOR.

146/100

Downing Street, London,
15th April, 1887.

SIR,—

In continuation of previous correspondence, I have the honor to enclose a copy of a Report by Sir John Coode (18th March, 1887) on the question of the proposed Harbor Works at Fremantle. The plan which accompanies the Report will be sent in a box as a parcel by the next mail steamer, being too large for enclosure in the mail bags.

I have, &c.,
W. F. OMMANNEY.

The Honorable the Colonial Secretary,
&c., &c., &c.,
Western Australia.

Sir John Coode to Crown Agents.

Fremantle Harbor.—Western Australia.

5, Westminster Chambers,
18th March, 1887.

GENTLEMEN,

Inspection of Site.

Acting upon the instructions conveyed in your letters of 14th and 17th February, 1885, I visited Fremantle in the following July and August, and was engaged for nearly five weeks in making inspections of the coast in the vicinity of the town, in examining Gage Roads, Owens Anchorage, and

Cockburn Sound, and in investigating the physical characteristics of the River Swan between Perth and the sea. My attention was particularly directed to that portion of the River known as Rocky Bay, about two miles above Fremantle, where it has been proposed to cut a channel or canal, in order to form a new entrance, so that deep-drafted vessels might proceed direct to Perth.

I also personally inquired into the sources of materials suitable for Harbor Works, visiting the quarries near Fremantle, the fine outcrop of granite at Cape Horn on the Railway, about twenty-five miles from Fremantle, and the magnificent jarrah forests, the latter being fully equal to supply timber of the finest quality and in unlimited quantity for sea structures where piling has to be employed.

Having been consulted in 1877 on Harbor accommodation for this Port, I had in view the special features and peculiarities of the site, more particularly the effect of structures, sheltering or otherwise, on the movement of sand at and near the coast line, the sea action, and the intensity of the wave-stroke to which works would be exposed; these points I carefully investigated on the spot, as also the extent to which the trade of the district is hampered by the absence of suitable accommodation for berthing ships.

Instructions for Special Survey.

Having completed my examination of the locality, I prepared a memorandum describing in detail the particulars of a survey and observations which I found to be necessary for the purposes of my Report, the information available being too meagre and unreliable to enable me to frame any project for improved accommodation, and more particularly for arriving at a definite estimate of cost.

With the sanction of His Excellency the Governor, Sir F. Napier Broome, I placed this memorandum in the hands of the Director of Public Works, the Hon. J. Arthur Wright, in order that the operations might be conducted under his supervision. The plans, sections, and documents were prepared accordingly without loss of time, and were delivered to me in June of last year.

Supplementary Instructions for further Borings.

Upon examining the new information at hand from Mr. Wright, it became evident that the results of the borings, which were made immediately seaward and southward of the mouth of the Swan, were of such a character as to cast a doubt on the origin and composition of the "Success" and "Parmelia" banks. I had previously thereto considered that these shoals, which are of remarkable shape, were merely accumulations of sand, and that their existence afforded strong, if not conclusive evidence, of sand-travel to the southward and of the shoaling which would consequently result from the construction of any *solid* works extending *directly* from the shore. The new borings conveyed indications of a coralline formation in some spots seaward of the embouchure of the Swan, and raised a doubt in my mind as to the possibility of the banks in question being due to coral growth.

It will be readily seen that had this view been borne out by subsequent investigations it would have exercised an important influence in determining the character of any sea structures, or works, at or near Fremantle, and, although I strongly inclined to the opinion that the banks in question were sand growths, the important issues at stake as regards the welfare of the district and of the Colony at large were in my opinion sufficient to justify the prudent course of removing, by actual and special examination, the doubt which had arisen, feeling as I did that the delay which would be entailed thereby would be infinitely less objectionable than to put forward a proposal as to the success, or satisfactory action of which a doubt existed.

I consequently framed a further memorandum to Mr. Wright, dated 14th August last, requesting that borings might be made through the Success and Parmelia banks, in order that their character might be clearly and unmistakeably ascertained. The results of the examinations which were accordingly made reached me on 5th January and on 7th ult., and from these additional particulars it is now clear that the banks referred to are accumulations of sand, and although the records of depths taken from time to time by the Admiralty authorities are not sufficiently numerous to enable their growth to be clearly traced and defined, nevertheless sufficient data are at hand to show that in all probability they are fed by the preponderating southerly movement of sand through Gage Roads and along the coast.

Having now been placed in possession of full information on all points, I am in a position to lay before you the following remarks and recommendations, with such a degree of confidence as the circumstances of the case demand.

Accompanying Drawings.

This Report is accompanied by three Drawings, viz.:—

No. 1.—A general Chart of the approaches to Gage Roads, extending from Rottnest Island on the North, to Warnbro' Sound on the South.

No. 2.—A detail Chart of Gage Roads and the embouchure of the Swan River.

No. 3.—A Plan, on a scale of 200 feet to an inch, compiled from the new survey made especially for the purposes of this Report.

On each of the above named drawings the scope and character of the works, to which I shall refer hereafter, are indicated by red, brown, and green colors respectively. Although the soundings on Drawing No. 3 are amply sufficient for the purposes of this Report, should it be decided to act upon my recommendations it will be requisite that a more minute survey of the sea bed should be made before proceeding with any actual works of construction. It is not probable that such further soundings would render necessary any appreciable alteration either in the lines of the works or in the estimate of cost.

Previous Report and Recommendations.

In my Report of November, 1877, I described at length the numerous proposals which had been made up to that time for improved Harbor accommodation. These may be briefly summarised as follows, viz.: 1st, Works contemplating the provision of the required accommodation elsewhere than at Fremantle; 2nd, Works for the improvement of the River lying between its embouchure and the bridge which carries the road to Perth; 3rd, External works running from the shore into deep water; 4th, Open piled jetties; 5th, Solid sheltering Breakwaters detached from the mainland.

Having considered these several designs, I arrived at the conclusion that the form of work, at that time, best suited to fulfil the conditions of the case would consist of an open timber viaduct 1,800 feet in length, extending from Arthur Head in the direction of the Beagle Rocks, terminating with a ⅂ shaped solid pier, the two arms of which would be of the aggregate length of 1,500 feet. In addition to the foregoing I proposed a spur jetty of 300 feet in length, to be formed at the junction of the viaduct with the solid pier, so that the total amount of berthage under this project would have been 1,800 feet in a depth of from 20 to 27 feet at low water. I estimated the cost of the undertaking at £242,000.

Although I referred at length in my Report of 1877 to the projects which had been put forward up to that time, it is desirable that I should here make special reference to the suggested formation of a deep water approach to Cockburn Sound; also to the proposed canal and new entrance at Rocky Bay, and to the practicability or otherwise of improving the existing entrance to the Swan to a sufficient extent to admit of the ingress and egress of trading vessels and coasting steamers.

Deep Water Approach to Cockburn Sound.

Probably the best entrance into Cockburn Sound is that through the Challenger Pass. This Pass could not, however, be improved at any reasonable expenditure so as to convert it into an approach to Cockburn Sound which would be available in all weathers. Nor is it clear that if so formed—the practicability of which there is reason to doubt, having regard to exposure and the presence of rock—that it could be maintained in its improved form.

The borings through the Success and Parmelia Banks have shown, as before stated, that they consist almost entirely of sand. Any channel which might be formed through these shoals would inevitably necessitate frequent dredging for maintenance, and, as I pointed out in my Report of 1877, such an approach would be impracticable and dangerous in a gale from the West, when the wind would be directly across the line of channel, and it would be impossible to confine vessels to the deep water track. Notwithstanding the fine sheet of water which exists in Cockburn Sound, the difficulties attendant upon the formation and maintenance of suitable and safe approaches are so great and would be accompanied with such a large expenditure, both in first cost and maintenance, that there will be no alternative but to consider the utilisation of the shelter and deep water there as entirely unattainable.

New River Entrance and Canal at Rocky Bay.

I gathered when in the Colony that it was desired I should consider, in common with other projects, a proposal made as long ago as 1874, to connect the River Swan and the sea by means of a direct channel or canal opposite the remarkable indent in the River known as "Rocky Bay," which is, as I have before stated, about two miles above Fremantle. The distance between the sea and the river at this point is but little more than 2,000 feet at the narrowest part of the neck of land which separates them.

It appears to have been assumed that the conditions are more favorable to this project than I find them to be. For instance, it has been taken for granted that from Rocky Bay to Melville Water there is sufficient depth for the largest vessels. I find however, upon reference to a survey made by the officers of H.M.S. Beagle in 1841, which is the most reliable information available on this subject that I am aware of, that for about three miles below Perth there are many parts of Melville Water where the depth is only from 1 to 1½ fathoms, and this was confirmed by some general observations made at the the time of my visit.

Again, the average height of the ground between Rocky Bay and the sea has been taken by the promoters of this project as 15 feet or less and "the distance 400 yards," whereas the actual *average* height is 24 feet, and the distance between the River and the sea 700 yards.

The foregoing objections could no doubt be met by greatly increased outlay on the undertaking, corresponding with the additional work involved. There are, however, defects of a far more serious character associated with this proposal, which, in my opinion, place it beyond the pale of practicable projects. I refer to the imperative necessity of associating with the proposed Canal the execution of moles or sheltering works, extending from the shore into deep water. Arms of this character, with other works required in connection therewith, are necessary not only for the provision of a fixed entrance in the requisite depth, but also to protect vessels in bad weather when approaching the Canal. The cost of such sheltering works would of themselves considerably exceed that of suitable structures, adapted to meet the required wants, if undertaken in the proper position, and therefore on this ground the adoption of the project is inadmissible. There is, however, still another grave objection, which would be applicable also to a corresponding treatment of the existing entrance to the River, viz.: that in consequence of the very limited volume of tidal and back-water available for scouring purposes, there are strong grounds for anticipating that a sand bar would grow up at the improved entrance, which would not improbably seriously prejudice its utility. Upon these main grounds, therefore, I am decidedly of opinion that the "Rocky Bay" project is not by any means a feasible one.

As to improving the existing entrance to the Swan, to make it available for sailing vessels and steamers.

The practicability of improving the existing entrance to the Swan River has, of course, engaged my anxious and careful consideration. It will be observed, on referring to the Drawings, that the mouth of the river is blocked, to a considerable extent, by a rocky barrier which extends completely across the entrance, the centre portion being dry at low water. The new borings which have been taken under my direction have determined the surface of this rock. From these it appears that to form an approach through the rock, having a depth of, say, 18 feet only at low water, would necessitate the cutting of a channel, entirely by submarine blasting, of 2,100 feet in length, 150 feet in width, and 11 feet in depth. Allowing for the scend or undulation in such an entrance, 18 feet would only be sufficient for coasting steamers and such craft as now use the jetty at Anglesea Point.

Rock removal under such conditions would be a work of considerable difficulty and attended with an expenditure which would be altogether disproportionate to the benefits to be derived from the deepening. But the more serious objections, which I have already pointed out in connection with the Rocky Bay project, apply with almost equal force here. I refer to the necessity for costly sheltering works and to the probability—nay, I might almost say the certainty—that looking at the large quantity of sand in motion, particularly near the coast line, the limited back-water available for scouring purposes would prove insufficient, even when aided by training and protective works, to keep open a deep channel through the rock barrier after the latter had been formed.

A reconsideration of this question, now that I have had an opportunity of personally examining the site and of studying the further data which have been provided, has tended to confirm the views expressed in my Report of 1877, viz.: that the conditions are so adverse that it is quite impracticable to treat the existing entrance to the Swan with a view to the formation and maintenance of a deep-water approach from the sea with any degree of success, and that any operations of this character, except to the limited extent to which I shall hereafter refer, would be attended with failure and disappointment.

Principles which should govern the determination of the position and character of Harbor Works at Fremantle.

Before describing the works which appear best adapted to meet the conditions and wants of the District, I may be permitted to touch upon a few of the leading principles which have been kept in view in framing my design. First then I desire to reiterate the opinion that nothing short of insuperable physical difficulties would warrant the undertaking of Harbor Works elsewhere than in the vicinity of Fremantle. Although the site there is undoubtedly an unfavorable one, as regards distance from the shore of a suitable depth of water, movement of sand, and position of outlying rocks, still these drawbacks can be satisfactorily overcome when framing a design, provided full particulars are at hand as is the case here.

There is at present no shelter at this Port, and the landing accommodation which is available, irrespective of that on the Southern bank of the River, is mainly afforded by the jetty from Anglesea Point. This jetty is capable in fine weather of accommodating vessels drawing about 12 feet, and then only at the outer end. Coasting steamers come alongside to land and embark passengers and cargoes, but in bad weather they have to haul off. Vessels drawing more than about 12 feet lie in the Roads, and discharge into or load from barges and small craft lying alongside.

It is obvious that the inconvenience and expenses arising from want of sheltered berthage and insufficiency of depth of water at Fremantle Jetties must increase as the trade of the Colony advances. It is no matter of surprise, therefore, that a strong and growing feeling exists as to the great importance of providing such artificial works as would admit of the safe berthage, discharge, and loading of large steamers and sailing vessels in all states of the weather, and of the tide.

Gage Roads are open to the full stroke of the seas from North to North-west; between the latter point and South-west they are in some degree sheltered by Rottnest Island, the Stragglers Reef, and the adjacent rock patches. Southward of South-west efficient shelter is afforded by Garden Island and the projection of the mainland, which forms the South shore of Cockburn Sound.

The heaviest gales commence from North to North-west and travel westerly to about South-west, by which time they usually abate. These gales bring in heavy seas, which are broken to some extent when from West to South-west by the patches of rock and foul ground before alluded to.

It will be seen from the foregoing that shelter is required over an arc extending from North to South-west, and although the outlying rocks break up the seas to the westward, nevertheless, I was informed that protection from this quarter is most wanted, and my observations were confirmatory of this view. The prevailing winds are northerly in winter, and southerly in summer, so that the roads are open to the winter seas.

I may observe that whilst at Fremantle I had an opportunity of witnessing the effect upon the sea in Gage Roads of a very strong gale from North-west, so strong indeed that it was represented to me at the time as causing the heaviest sea that had been seen there for some years. This occurrence was so far fortunate as it enabled me to form a correct idea of the wave-stroke that would fall on artificial works in a gale of unusual severity.

Looking at the results of the supplementary borings on the Success and Parmelia Banks, it would not be prudent to construct any solid structure in direct connection with the shore. To provide for the unimpeded movement of the sand, it will be requisite that any sheltering work at Fremantle should be detached from the mainland, the connection with the shore being effected by means of an open viaduct so arranged as to admit of the unrestricted passage of the sand without causing its deposition. It is only

by keeping this point fully in view that deposits and possible failure may be averted. I particularly watched the effect of the existing open-piled jetties on the movement of sand, and can state that no silting has been occasioned by them, the sand oscillating backwards and forwards underneath the deck as freely as if the beach were open.

Sites for a Harbor which have been considered at Fremantle.

I have considered the relative advantages and disadvantages of three possible sites for a Harbor at and near Fremantle. The first of these lies between the entrance and Eleanor Rocks. There is an excellent area of deep water at this site, but the approach to a Harbor constructed there would be attended with danger, more particularly in bad weather, in consequence of the outlying patches and points of rock in the offing immediately to the Westward. Again, a work so far to the North would not be conveniently placed with regard to the town.

The second site to which I refer is between the Entrance Rocks and the Beagle. There is a fairly large area of deep water with clean ground both between the rocks named and immediately seaward thereof. I have designed a Harbor on this area, and have prepared drawings and an estimate of cost thereof. I find, however, that a larger expenditure would be required in order to provide the requisite accommodation on this site than on that to which I shall next refer, and, moreover, although a somewhat greater depth would be available in this position, there would be an insufficiency of sheltered area, and, further, there would be reason to apprehend deposits under the lee of the works, caused by the outrun of the river, and the consequent disturbance of sand in times of flood. It will be observed that this site is almost opposite the existing entrance to the Swan.

The position which, on the whole, will be found most advantageous, is that which I have selected and shown on the accompanying Drawings as the site of the proposed Harbor, and lies between the Beagle and Minden Rocks. The area enclosed possesses somewhat less depth than at the other two sites, but a much larger area of sheltered water would be provided than would be practicable elsewhere even at a greatly increased expenditure; the approaches are good, and free from obstruction, and there is no reason to apprehend shoaling or deposits in connection with the structures after their formation.

Proposed Works.

Having now described the general conditions to be borne in mind in determining the character of Harbor Works for Fremantle, and referred to the reasons which have led me to select the area within the Beagle and Minden Rocks as being on the whole the best site, it becomes necessary that I should describe the extent and character of the works whereby the desired shelter and accommodation would be provided.

I should, however, here mention that the Design which I have to put forward has been framed so as to admit of execution in sections, as the wants of the Port may demand and the finances of the Colony may justify. To provide for the execution of a fine Harbor, adapted for the reception of Mail Steamers, would doubtless be beyond the *present* means and requirements of the Colony; but I hold in laying out a work of this character, where the Port must inevitably grow with the advancement of the Colony, that it is of vital importance to so frame the design as to admit of the engrafting of length on length in order that ultimately a complete and comprehensive whole, adapted to provide for all future requirements, may be available. It is only by the adoption of a systematic mode of procedure such as here contemplated, that a reasonable prospect of success may be held out for the future, particularly where the conditions are so complicated as to sand movement and otherwise as are found to prevail at Fremantle. Although I propose to recommend only a portion of the project, but still one complete in itself, for adoption in the first instance, I have nevertheless considered it desirable to prepare a Design and Estimate for the entire undertaking.

The works I have to propose are shown on the Drawings by red and brown color respectively. The Design colored red is recommended for early adoption, and will, it is believed, provide all the accommodation which will be necessary during the present generation. The additions colored brown are intended to be made hereafter, if required, in order to increase the sheltered area and to convert the Port into a first-class Mail Station.

Upon referring to the Drawings it will be observed that the works to be undertaken in the first instance consist of a Root, a Viaduct, and a Pier. The Root would be formed by excavating the material at Arthur Head over the area colored red, where above the level of the viaduct deck. To the North-west of the termination of the new sea wall which has been recently constructed near the shore end of the existing Jetty, a sloped face, pitched with stone, would be formed as shown, the area at the back of the slope being raised to viaduct level by means of material obtained from the excavation above described. From the South-west angle of Arthur Head I propose to construct a substantial wall, with a "return" to the northward to join the existing rock face. This wall would form the seaward face of the Root, and also an abutment from which the Viaduct would start. It will be seen that the Root, as designed, contemplates the provision of a convenient and spacious approach from the town to the Pier, and would also afford, after the completion of the works, valuable sites for offices, warehouses, &c.

The Viaduct would be formed almost entirely of jarrah timber. It would commence at the abutment wall at Arthur Head in 11 feet at low water, and extend therefrom for a length of 1,600 feet, practically in the direction of the Beagle Rocks, terminating in 20 feet at low water. The deck of the Viaduct would be at an uniform level of 15 feet 4 inches above low water, or 12 feet 4 inches above high water, and would thus be about 15 inches higher than the platform of the existing Jetty. The bays or tiers of round jarrah piles would be 14 feet apart centre to centre, five piles constituting a tier. Stiffening bays

would be introduced at suitable intervals, in order to afford the requisite lateral rigidity for a work of the length proposed. The deck throughout would be 31 feet in width and furnished with two lines of railway, laid on the Colonial gauge of 3′ 6″, provision being made in proportioning the strength of the structure for haulage by small locomotives.

From the outer end of the Viaduct I propose to construct a ⅂ shaped pier, formed of blocks of concrete, or rubble masonry, built as a solid structure, the harbor face being adapted for berthage, and the sea face furnished with a high sheltering parapet. The inner, or East-and-West arm of this Pier would extend in direct prolongation of the Viaduct for a length of 1,100 feet, it would then turn in a direction practically North-and-South for a further length of 1,400 feet. There would thus be 2,500 feet of sheltered berthage under the lee of this work in from 22 feet to 29 feet at low water, the arm in continuation of the Viaduct affording complete protection from the North, whilst the outer portion would furnish perfect shelter from the West.

It will be remarked that the design I have described is practically of the same character as that put forward for adoption in 1877. Upon comparing the two projects, however, it will be observed that although the sites and the principles upon which the two designs are based are nearly identical, I have found it necessary, in view of my local inspection and inquiry, to increase the area to be sheltered by adding very materially to the lengths of the solid structures and also to provide for a Concrete Pier throughout, instead of forming the outer portion of piling filled in with rubble, as proposed in 1877. Having now had an opportunity of witnessing the force of the sea which would have to be encountered by these works, I am satisfied that nothing less substantial than structures of solid concrete would meet the conditions of the case in a permanent and satisfactory manner. In my design of 1877, I proposed that the arm in continuation of the Viaduct should be of concrete; experience of the locality would have shown, ere this first length were completed, that the remaining portion, instead of being a "crib" structure of piling filled in with rubble stone as intended, should also be carried out in concrete, thereby providing for the security and permanence of the Pier, but at the same time increasing the cost.

The concrete Pier would be 37 feet wide at coping level throughout, but as the North and South arm would be furnished with a higher and more massive sheltering parapet than the length in prolongation of the Viaduct, the quay surface would be 28 feet in width in the former case, and 30 feet wide in the latter. The surface of the Pier throughout would be about 3 feet 4 inches below the deck of the Viaduct, communication between the two levels being provided by means of an incline, adapted for locomotive traffic, to be formed at the inner end of the concrete work.

The Pier would be furnished with fenders, bollards, boat steps, and a substantial head and lighthouse. It would be founded throughout on sandstone rock, a protective apron of cement concrete, laid in bags, being provided along the footings of the sea face, in order to prevent erosion of the surface from the run of waves along the back of the structure.

The blocks for the Pier would be made in the workyard which it is proposed to form on the sand-spit in the Swan, in the position indicated on Drawing No. 3, where also suitable workshops, cement shed, and other necessary structures would be erected. The area to be provided at the Root would be available for the preparation of the timbers, &c., for the Viaduct; suitable plant embodying all modern improvements would be supplied for the proper and economical execution of the undertaking.

I estimate the cost of the foregoing works colored red on the Drawings, viz.: the Root, Viaduct, and Pier, with railways, moorings, and special plant complete, at £448,000. This sum is based on liberal rates, and would, I believe, be found amply sufficient. It includes an allowance for contingencies, and also engineering, local supervision, and all establishment charges.

Proposed Dredging.

I have shown on the Drawings by red crossed lines how the depth in the approach to the Pier and also over a portion of the area sheltered by it might, if desired, be increased by dredging to 26 feet at low water. It will be observed that the depth without dredging may be taken at 24 feet, there is however one spot marked as 22 feet at low water which would be deepened to 24 feet under the Estimate given above.

The datum, or zero, of the soundings shown on the drawings is low water of Summer tides. The range of tides throughout the year, *i.e.*, the difference between high and low water levels, may be put down as three feet, but mean low water in the winter is about 2 feet above that of the summer tides; hence, when the winter gales prevail, there will be a greater depth, by 2 feet, than shown on the Drawings. Notwithstanding this fact, the dredging of the area crossed by red lines would no doubt follow upon the completion of the Pier, but to carry out the work to the extent shown would necessitate the purchase of expensive dredging plant, and if the cost of this plant were debited entirely to these works, I estimate that an outlay of £47,000 would be required on account of the dredging, including the purchase and delivery of the plant. Looking at the existence of rock underneath the sand as indicated by the borings, it will not be practicable to reckon on a greater depth ultimately over the dredged area than 26 feet at low water of summer tides, or 28 feet at low water of winter tides.

The sum of £47,000, named above, provides for the dredging of the entire area crossed by red lines. Considerable benefit would be produced by the deepening of a portion of this area, thereby curtailing the outlay, but not to an extent directly proportionate to the work accomplished, seeing that under any circumstances the plant would have to be provided.

Future Extension.

The works proposed, and described above, will, as I have before named, be amply sufficient for all trade purposes during the present generation. There would be an abundance of quay space in a depth where trading vessels and steamers might be afloat at all periods of the tide, and where also they would

be securely and comfortably berthed in all weathers. The dredging suggested as an addition to the initial project would further increase the benefits to be derived from the works, but even with the increased depth available in consequence of this dredging, it will be absolutely impossible to provide for the regular accommodation of such steamers as those of the Peninsular and Oriental and Orient lines, unless by a very considerable increase of expenditure, which I would venture to suggest might well be deferred, at all events for the present.

To create a Port for the regular calling of Ocean Mail Steamers would necessitate the provision of a depth of at least 34 feet to 36 feet in the Entrance, in order to allow for the scend of the sea during gales. For it must be borne in mind that unless accommodation and space is provided to enable steamers of this class to call under *all conditions of weather*, it would be quite impracticable to create a Mail Station at this or any other port. Although, therefore, under the design shown by red color, a sufficient depth might be provided for the use of the Mail steamers in *fine weather*, in gales there would be no margin to compensate for wave undulation, and therefore the accommodation could not be made available under such conditions.

As I understood, when in the Colony, that the formation of a Mail Station was a point to be kept in view, I have indicated on the Drawings by brown color the scope and character of the further works which would be required to effect this object in a proper manner.

I have prepared quantity drawings of these additional Breakwaters, from which it appears that their cost complete would be £545,000 over and above the sum named for the execution of the works colored red. This additional sum contemplates the construction of a North Breakwater of pierres-perdues, 2,700 feet in length, extending from the northern salient angle of the proposed concrete Pier, and a detached South Breakwater over the Minden Rocks, also 2,700 feet in length, formed of rubble stone, with a capping of concrete, suitably arranged. As named above, I do not put forward these extended works for adoption, but have considered it desirable to state what outlay would be required to provide a mail station at Fremantle in view of the opinion entertained in the Colony on the subject. It will be observed that the depth requisite to render the Entrance available for Peninsular and Oriental and Orient Steamers is only reached at a distance of 5,500 feet from Arthur Head. I mention this fact as an indication of the magnitude of the works required.

Mode of executing Works.

Should the execution of the works colored red on the Drawings be authorised, I would strongly recommend that they be carried out departmentally, as was done at Colombo, the same general mode of procedure being adopted as was observed with regard to those works. I feel convinced that this course would prove in the end more satisfactory and economical than any other.

The execution of the complete project colored red would occupy from 8 to 10 years, over which period the expenditure of £448,000 would be distributed. One year at least would be required in preliminary operations, such as the formation of the workyard, erection of workshops, sheds, &c. The viaduct would be proceeded with pending the construction of the special plant and machinery, which should be sent out from this country through your department, as at Colombo, Castres, and elsewhere, for harbor undertakings. The blocks for the pier proper would be conveyed over the railways to be laid on the viaduct, therefore block setting in the pier would not commence until the viaduct had been completed.

Future small improvement of Entrance to the Swan.

Although, as I have previously stated, it is impracticable to improve the existing entrance to the Swan to such an extent as to make it available for coasting steamers and vessels drawing say 12 feet to 14 feet, still it may become desirable hereafter to provide small training works and to deepen the rock in the entrance to a sufficient extent to facilitate the navigation of barges and such like craft as are now engaged in the river traffic.

I have therefore indicated by green color on the Drawings the character of the works which would be required to effect this object. I may, however, state that in the absence of definite information with regard to floods and other data, applicable to this special feature of the investigation, it is not possible for me to do more at present than to indicate in general terms the character of the works, leaving their details and cost to be determined hereafter, should it be decided to take active steps in this direction. Moreover, I have considered, in view of the outlay required on the outer and far more important works, that it would not improbably be deemed inopportune to bring forward any collateral project requiring additional expenditure at an early date, unless the same could be clearly shown to be of a remunerative character, as to which I fear there is not sufficient evidence at present. The time will, however, undoubtedly arrive when some such works at the entrance to the Swan as those colored green will be undertaken, prior to which the further current and flood observations necessary to determine with precision the width of the entrance and other questions affecting these improvements should be at hand.

The top of the training bank shown on the south side of the channel would be kept at the level of ordinary high water of summer tides, which would be about mean half-tide level of the year, so that, during winter freshes, the outrunning waters would escape over this bank, and thereby obviate the creation of a gorge at the proposed mouth of the river.

In determining the width between the training banks, after the further data referred to are available, due regard should of course be paid to the formation of a channel of such capacity as would admit of the free discharge of flood waters, so that the tendency to flood the lower parts of the town

may not be intensified. The true remedy for the latter, however, will be found in raising the left bank of the Estuary at those points where necessary between the bridge and the entrance.

Protecting neck of sand Northward of Rous Head.

I must not omit to refer here to a matter which arrested my attention when at Fremantle, viz., the importance of protecting the narrow neck of sand immediately to the northward of Rous Head, in such a manner as to prevent its being breached by the sea. There is reason to apprehend that if such a breach were to occur, as long as it remained open even the small craft which now pass into and out from the river would be unable to do so.

Moreover a breach at this point, although it may be small at first, would, in all probability, soon become enlarged to such an extent as would admit of a considerable amount of sea disturbance within the estuary, thereby effecting changes in the distribution of the sands therein to the prejudice of the navigation and the free discharge of the flood water.

I suggested to Mr. Wright that a breach might be obviated, at a comparatively small cost, by the timely construction of stake-and-wattle work. The spot should, however, be carefully watched, and it may become desirable to further protect the River Bank along the weakest portion by a coating of rubble stone. To execute the training bank on the North side shown by green color would be an expensive piece of work, and its formation should be deferred until the treatment of the entrance is to be taken in hand.

Conclusion.

I cannot conclude this Report without expressing my great obligations to His Excellency the Governor, Sir Frederick Napier Broome, for the kind and ever ready manner in which he gave such instructions as facilitated my inspection and investigations whilst I was occupied in the Colony.

To the Hon. Malcolm Fraser, the Colonial Secretary, the Hon. John Forrest, the Surveyor General, and the Hon. J. Arthur Wright, the Director of Works (and particularly to the latter, within whose department the Surveys were made), my thanks are especially due for the prompt and courteous manner in which they severally responded to my applications for local information and aid.

I have, &c.,

(Sd.) JOHN COODE.

By Authority: Richard Pether, Government Printer, Perth.